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PROPOSAL FOR A

PROTOTYPE
PATCH RECTIFIER

Request for Quotation 0538-65

STAT

Proposal Number 151-65
February 25, 1965

ABSTRACT

This Patch Rectifier proposal describes a rectifying printer utilizing an unusual lensless optical approach for rectification, coupled with a conventional optical approach for providing a 4x magnification of the rectified image.

A 2-1/4" x 2-1/4" patch of a panoramic, oblique, or anamorphic photograph on a roll is rectified by point light projection onto a high resolution diffusion screen. This technique involves some resolution loss under extreme rectification conditions, but consequently yields a simple reliable device capable of very accurate rectification.

The rectified image on the diffusion screen is re-projected by a high resolution 4x optical system onto a fixed easel, which accommodates photographic paper up to 9-1/2" x 9-1/2". Frame scanning is performed by manual X-Y motion of the frame.

Additionally, an automatic exposure control is incorporated in the easel base plate.

The proposed design represents a complete, unique solution to the problem outlined in "Design Objectives for a Patch Rectifier," DO-315-RD65-2, 17 August 1964.

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PROPOSED DESIGN FOR A PATCH RECTIFIER

1.0 DESIGN CONCEPT

The proposed design for a rectifying printer is in response to RFQ Number 0538-65 to meet the design objectives outlined in DO-315-RD65-2. The proposed rectifier is capable of exposing 9" x 9" prints, which represent 4x magnification of rectified images of a portion of roll film photography.

A unique method of rectification is proposed which uses lensless projected by a point light source. For panoramic and tilted frame photography, the relative location of the point light source and the film comprise a reconstruction of the geometry of the taking camera. The light source and film comprise a 1:1 optical analog of the taking camera and are moved as a unit to permit rectification for tip and tilt distortion. The rectified image is projected onto a high resolution transparent diffuser. The rectified image can be viewed directly and can also be enlarged for printing. It is proposed to project the rectified image which appears on the diffuser surface, using a fixed focus enlarger having 4x magnification. The optical systems are therefore divided into the two separate stages -- rectification and magnification.

The use of a lensless projector for the rectification stage avoids many of the cumbersome and complicated linkages of conventional rectifying printers. Since a lensless projector has no focal plane, autofocus mechanisms are eliminated completely. Therefore, the film can be freely rotated, tipped and tilted without the usual requirements for meeting the Scheimflung condition.

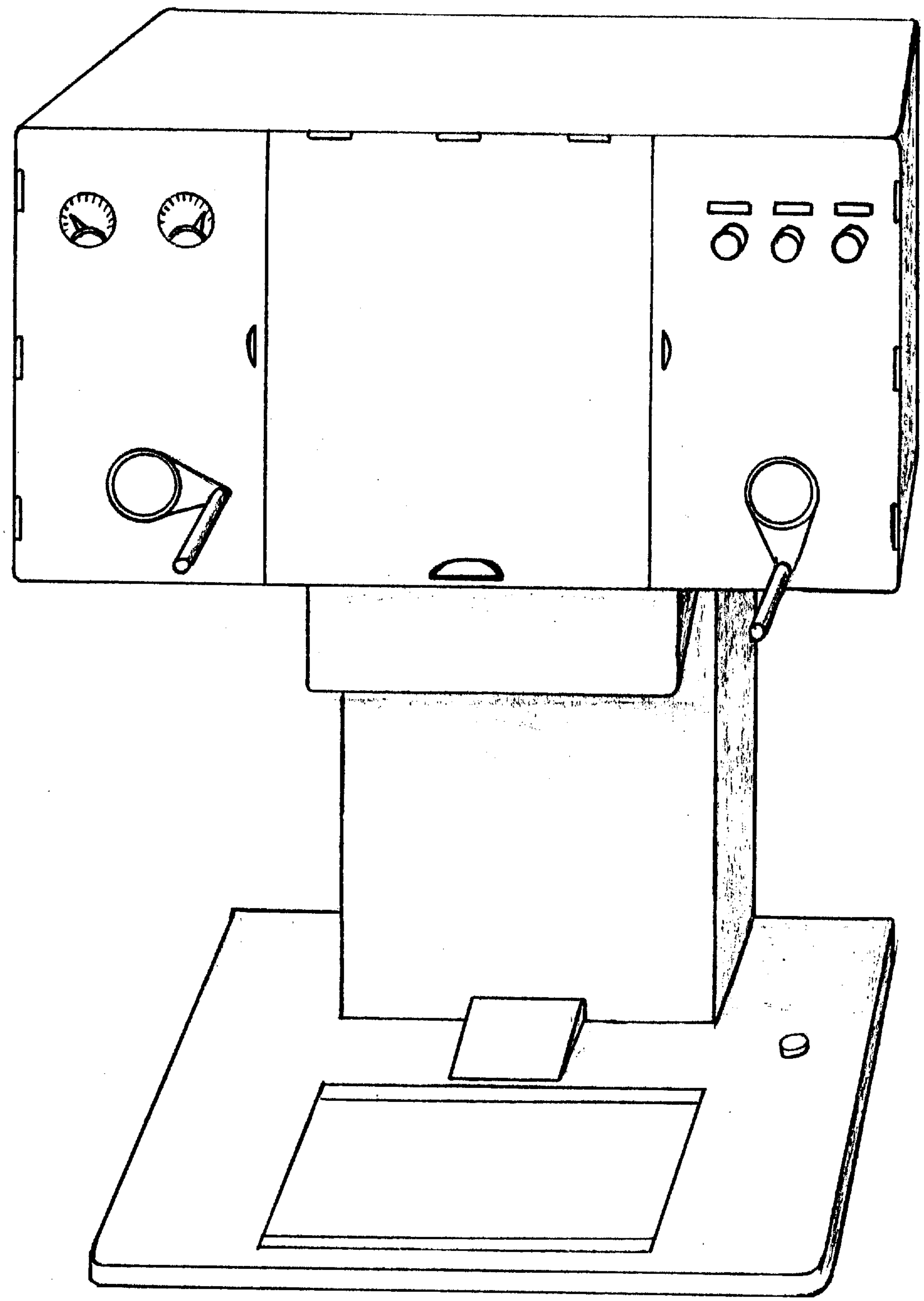
The magnification stage is reduced to one with very simple performance specifications. Being fixed focus, a conventional wide aperture lens can be used, having resolution characteristics well above the stated requirements. Since the lens is not required to operate at excessively wide angles, geometric distortion, spherical aberration and coma are easily minimized by choice of a relatively long focal length.

It is proposed to include an automatic exposure control to compensate, during printing, for variations in average negative density.

In summary, the proposed design includes separate stages for rectification and magnification, wherein the rectification is accomplished without the use of a lens and the complex mechanical linkages it would require. The magnification stage is straightforward. The overall design represents a complete optical solution leading to a relatively simple, lightweight and compact unit.

Figure 1 is an artist's concept of a possible Patch Rectifier Configuration; Figure 2 is a schematic showing the patch rectifier setup in each of its three operating modes.

Figure 1. Patch Rectifier



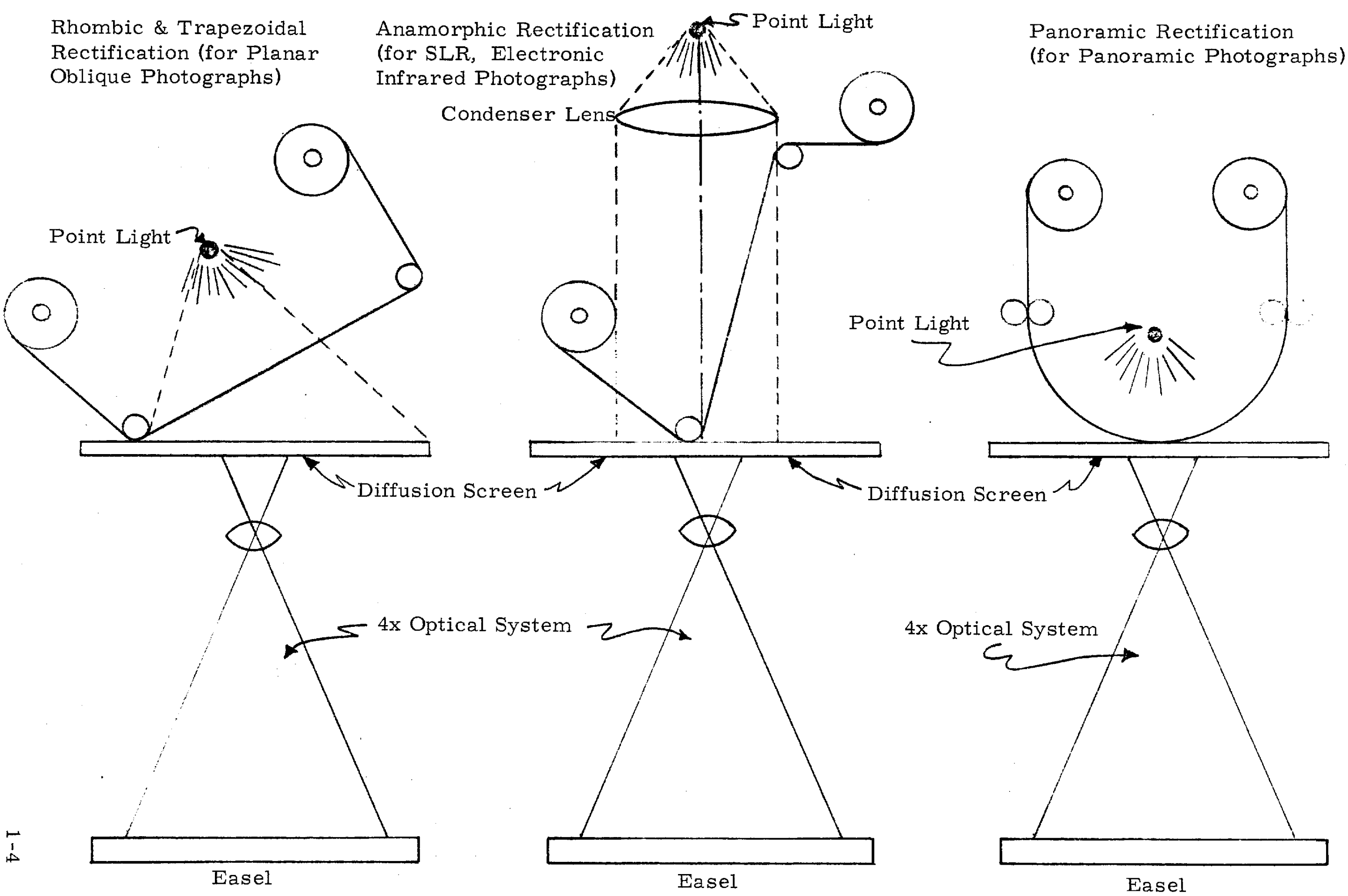


Figure 2. Schematic of Three Setups of Patch Rectifier

2.0 DESIGN DETAIL

A. Light Source: The most important property of the light source in the proposed design is its size. It must be very small, yet bright. Therefore, it is proposed to use either zirconium or a mercury concentrated arc lamp. Either type is considered suitable for lensless projection of high resolution images. The chief difference is the color of the emitted light. Zirconium, being an incandescent arc, emits light over the full visible spectrum. However, for printing efficiency, the mercury arc is preferred due to its rich emission in the ultraviolet and blue portion of the spectrum.

The design objective specifies a moderate exposure time, not to exceed two minutes; but does not specify the photosensitive material to be used on the easel. It is assumed that high speed orthochromatic emulsions on either paper or film base will be used in the printer.

Uniformity of an exposure over the entire printed area is an inherent feature of the proposed design. Unlike conventional rectifiers, image brightness is not always a function of local magnification of the rectified image. On the contrary, brightness can be constant over the surface of the diffuser which receives the rectified image regardless of the position of the negative during rectification. This, in turn, allows a uniform exposure over the entire surface of the printed area.

Since the rectified image can be viewed directly at the surface of the diffuser, no auxiliary light source is needed for empirical orientation purposes.

B. Film Gate: Ordinarily, the use of a liquid imersion film gate leads to inconvenient operation. In a projection system which uses a diffuse light source, liquid imersion is seldom warranted. However, lensless projection by means of a point light source depends on specular transmission and a liquid imersion film gate once more become desirable; therefore, it is proposed to include its use as a design goal. Design of the gate will be relatively simple for use with films held in a plane (between glass plates) during the rectification process. However, for those types of rectification which require curving the film (discussed later), liquid imersion may not be feasible.

C. Film Transport: The film transport will be designed to accommodate rolls of film up to 500' in length in standard widths of 70 mm, 5" and 9-1/2". Hand cranks will be provided for manual transport in the x direction and will include pressure pads to lock the film in position. The entire transport unit will be movable in the y direction for visual patch selection. The transport will also be rotatable, about two axes to rectify the pitch and roll during initial photography.

D. Optical System: The proposed optical system contains two separate and independent stages of projection. The first stage is lensless projection by means of a point light source, and is used exclusively for rectification of the image. The rectified image is projected onto a high resolution diffuse transmitter, such as uniformly exposed and developed Kalvar film. Kalvar is normally used to record microfilm images and is reported to have resolution on the order of 100 lines per millimeter. At this point in the optical train, the rectified image is very nearly the same size as the image on the negative, except for the local variations in magnification required by the rectification process. Due to the use of a point light source, resolution of the image at this surface can approach that obtainable in a contact printer. The resolution falls from this value as a function of the separation between the negative and the diffusing surface and also as a function of the size of the point light source.

The rectified output of the first stage, the diffusion screen image, becomes the input to the second stage. The second stage is a fixed focus enlarger, using a conventional high resolution projection lens, with image and object distance selected to give a constant 4x magnification of the rectified image transmitted by the diffuser. The enlarged image is projected onto the easel for printing.

D1 Rectification: It is proposed to accomplish all of the specified types of rectification by using point light lensless projection. In effect, this becomes a shadow casting optical system, wherein rectification is accomplished by appropriate positioning of the film in the path between light source and diffusing screen. The design takes advantage of the fact that a lensless projection system has no focal plane, and hence permits infinite variability of the position and orientation of film in the optical path. The design also takes advantage of the fact that film is a flexible material and need not be held in a flat plane during projection. Instead, the film may be curved to accomplish the non-linear rectification required for panoramic photography and side looking radar.

A more detailed explanation of point light rectification is given in Data Systems Engineering Proposal Number 106-64, Point Light Rectifying Printer for Panoramic Photography, 21 January 1964 and Proposal Number 147-65, Line Rectification System, included as Appendices I and II.

D1:a <u>Anamorphic:</u> The origin of photography requiring anamorphic rectification is not stated in the exhibit. Therefore, it is assumed that the primary source of such photography is derived from continuous strip cameras in an airborne platform. Side looking radar, scanning infrared photography and continuous strip optical cameras all require motion of the film at a rate proportional to ground speed of the aircraft. When the film rate does not match lateral magnification, the ratio between the magnification along the X axis and the Y axis is not unity. Hence, anamorphic distortion results and rectification becomes necessary for accurate measurement and/or comparison with undistorted imagery. For this type of rectification, it is proposed to use a point light source and a collimating lens of sufficient diameter to cover a 2-1/4" x 2-1/4" square. The film is placed in the collimated beam between the lens and diffuser. Tilt of the film will determine the ratio between X and Y dimensions. The film is held in a flat plane and tilted when rectifying continuous strip optical or infrared scanning photography. Furthermore, the film may be non-uniformly curved when rectifying side looking radar photography to correct the difference between slant range and ground range. The specified range of 1x to 5x for the magnification ratio between X axis and Y axis imagery seems to be excessive for rectification of the types of photography assumed. However, this range can be accommodated with the proposed design. A loss in resolution is to be expected for the extreme ratios.

D1:b Rhombic: Rhombic distortion occurs in oblique frame photographs whenever a combination of pitch and roll exists in the camera installation and/or aircraft altitude. The proposed method of rectification requires reconstruction of the geometry of the taking camera by locating the point light source at a position comparable to that originally occupied by the lens center. The light source and film are then moved as a unit about the axes of rotation to effect the required rectification. Since complicated autofocus mechanisms are not involved, the unit can be freely tipped or tilted to reconstruct the angles of pitch and roll of the original photography. It is therefore unnecessary to provide the 360^{o} of "swing," which is generally required in a rectifier capable of tilt about one axis only. Since "swing" is not required by the proposed design, it is not included at the proposed price and delivery. However, if it is deemed desirable to include "swing" as a means of achieving uniform North orientation, a supplementary proposal can be submitted upon request.

D1:c Trapezoidal: Aerial frame photography produces distortion when either pitch or roll exists alone. Trapezoidal distortion is therefore a restricted case of Rhombic distortion. In operation, pure trapezoidal distortion is seldom encountered, since the aircraft always exhibits a combination of pitch and roll. However, it is traditional to combine rotation about these two axes into rotation about their resultant axis. In rectifiers where the easel is able to tilt about one axis only, the image is rotated so that the resultant angle of pitch and roll is parallel to the tilt axis of the easel. In such rectifiers, a swing of 360^{o} is required, in order to orient the frame for all possible combinations of pitch and roll angles. As previously mentioned, "swing" is not required or proposed. Nevertheless, the proposed design is able to rectify either rhombic or trapezoidal distortion due to the ability to rotate the frame about both its X and Y axes.

As previously noted, the rectification and magnification stages of the optical system are separate and independent. The output of the rectification stage is the image projected onto a high resolution diffusion screen. This same image becomes the input to the magnification stage; and, since the image is already rectified, does not require movement of any of the elements of the fixed focus projection system. Consequently, it is not necessary to tilt the printing easel.

D1:d <u>Panoramic:</u> Provisions for panoramic rectification are essentially the same as those for rhombic and trapezoidal rectification of frame photography. Again, the only requirement for rectification is to reconstruct the geometry of the taking camera. For panoramic photography, this is accomplished by curving the film at the same radius of curvature used in the taking camera and locating the point light source at the center of curvature. Once this is accomplished, panoramic rectification occurs in the image projected by the point light onto the plane surface of the diffusion screen. As before, the complete unit, consisting of light source and film, can also be tipped and tilted to correct for rhombic distortion resulting from pitch and roll of the aircraft. A model of a simple rectifying viewer to accommodate 5" wide panoramic photography taken with a 3" focal length lens, has been constructed [redacted] The model uses a STAT
25 watt zirconium concentrated arc lamp to demonstrate the feasibility of rectifying panoramic photography by means of point light projection. The model is available for demonstration, as an aid in evaluating this proposal, and will be provided upon request.

E. Easel: Since the magnification stage is not involved in the rectification process, the easel becomes a simple device for holding the sensitive material during exposure. The easel will be designed to accommodate cut sheets of film or paper 9-1/2" x 9-1/2" square. This will leave a 1/4" border on all four sides and will provide an unobstructed printing area of 9" x 9".

Since the distance from lens to easel will be on the order of 20" to 30", the requirements for holding the sensitive material flat are not severe. Hence, it is proposed to use simple edged guide channels to hold the paper or film in position during the exposure.

It is expected that exposure times will be on the order of 1 to 2 minutes. Hence, it is proposed to control exposure time by means of an electromechanical shutter in the optical system. To assure uniform exposure, it is proposed to equip the easel with an integrating light meter to automatically control duration of the exposure.

F. Controls: The principal controls required for the use of the proposed patch rectifier are located in the vicinity of the film transport. These include hand cranks for transport of film, locks for holding the film in position, cranks for independently tipping and tilting the film and a crank for positioning the point light source at the proper distance relative to the film. A push button to initiate the exposure will be located in the vicinity of the easel for ready access by the operator.

G. <u>Electrical Requirements</u>: The system will be designed to operate on a 110 volt, 60 cycle, AC current. No electric motors are envisioned in the design. The only power requirement is for the light source, light meter and solenoid acuated shutter. It is estimated that less than 100 watts will be required.

H. <u>Clarifications:</u> The document entitled "Design Objective for a Patch Rectifier" DO-315-RD65-2 dated 17 August 1964 is a brief statement of the requirements for a general purpose rectifying printer. The proposed approach, using a point light source for lensless projection, is not only novel but offers the possibility of an extremely simple and compact equipment. The government has already spent considerable money on development of a variety of extremely complicated, cumbersome, and expensive rectifiers, which, in production, would cost many times as much as the proposed device and would have far less capability.

The proposed design, although exceedingly simple in concept, is in the very early stages of development. During the program, a few limitations will surely be discovered. These may prevent reaching some of the design objectives. Nevertheless, the development of this equipment has been requested for a fixed price and is proposed on that basis with the understanding that the delivered item will represent the "best efforts" [redacted] to meet the stated objectives. Performance limitations will be encountered and engineering compromises will be necessary. Decisions required under such circumstances will be the responsibility of [redacted] and will reflect a conscientious effort to deliver satisfactory equipment at a reasonable profit. STAT

I. Delivery: It is proposed to deliver one (1) Patch Rectifier, as described above, constructed in accordance with best commercial standards, within 9 months from date of contract.

3.0 PROGRAM MANAGEMENT

STAT [redacted] believes in and practices the concept of strong program management. The corporation designates a Program Manager with a line organization under him to accomplish the specific program tasks and objectives.

As shown in the Figure on the following page, the Program Manager reports directly to the Corporate Director of [redacted] STAT

STAT [redacted] An appropriate staff will be created from the [redacted] operation and STAT from the operating corporate divisions, by direct assignment of skilled personnel. This management team, at the corporate level, will direct all activities required to complete the program.

Program Manager

The total responsibility for accomplishment of the program is focused in one man, the Program Manager. He is internally responsible to the Corporate Director of [redacted] and externally STAT responsible to the customer. He is provided with the authority necessary to accomplish and control all aspects of the program. His office is a single focal point, highly placed in the corporate structure.

The Program Manager defines the entire program in a comprehensive program plan which contains work statements, assignments

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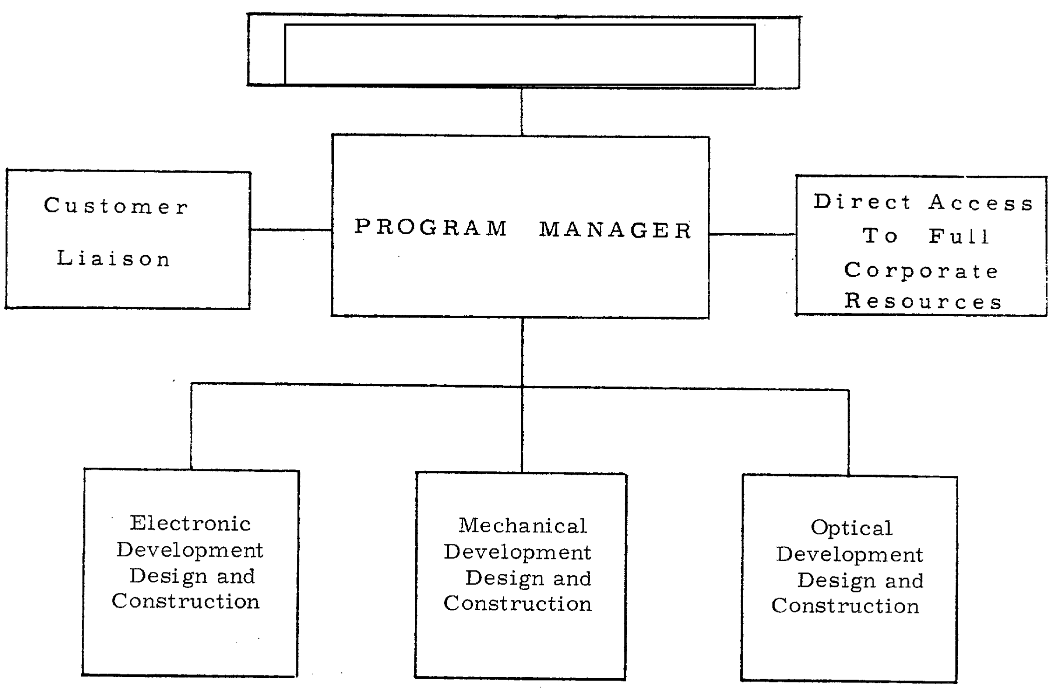

Figure 3

PROGRAM MANAGEMENT CONCEPT

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of responsibility, schedules, budget allocations, and authorizations to proceed. He guides the performance of his team, using this plan and the detailed controls derived from it.

For each specific program, an individual possessing an extensive background in program management and engineering is chosen to fill the position of Program Manager, which [redacted] believes to STAT be a critical area in the proposed program. The Program Manager, and the selected group leaders reporting to him, would remain with the proposed program from inception to completion.

STAT 4.0 [redacted]

STAT [redacted] is an autonomous corporate group of the [redacted] STAT
STAT [redacted] organized to design, develop and manage integrated
intelligence and reconnaissance systems for space, naval, airborne
and ground applications. The group has access to the full range of
STAT [redacted] resources, including facilities, technical
personnel, management and financial support.

The group was established by [redacted] to help meet the STAT
growing demand for professional and technical services, hardware,
special studies, and analyses pertinent to advanced data systems,
particularly the acquisition, interpretation, storage and retrieval of
intelligence and reconnaissance information. Recognizing the importance
of having these services and talents convenient to the nerve center of
the U.S. defense establishment, [redacted] located the new group STAT
in greater Washington, D. C.

STAT Formation of [redacted] has allowed [redacted] to round out its STAT
capability to develop complete aerospace systems by recognizing recon-
naissance and intelligence as a separate major technical and operational
area. Toward this objective, [redacted] has committed its total STAT
corporate resources.

Concept

The concept of [redacted] includes the following STAT
basic features:

1. Composed of highly qualified technical, operational and management personnel with broad industrial and military experience in areas requiring the highest security clearances.

2. Full autonomy of operations in a separate facility tailored to meet the customer's security standards.

3. Postured and oriented to provide quick reaction services, research and development, systems design, special studies, maintenance, modification, and overhaul projects; and to provide technical assistance to supplement Government laboratories and installations.

4. Access to a broad base of corporate laboratory and manufacturing facilities, scientific and technical people and strong financial and management support.

5. Close geographic proximity to most customers, permitting close and continuing liaison and coordination with Government engineering and management personnel with quick reaction at inherently low cost.

6. Maximum emphasis on reliability, quality control and simplicity of design.

7. Direct access to and use of consulting scientists of national reputation residing in the area.

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Areas of Interest

1. Research, engineering and development of photoelectric data processing systems and components for image interpretation and graphic reproduction.

2. Advanced concepts, studies and analysis of data systems and data handling techniques; operations analysis of intelligence and reconnaissance systems.

3. Systems integration of aerospace and ground support equipment including technical direction and coordination of design, development and production of major components and subsystems, both within the facilities of [redacted] and at other companies.

4. Maintenance, modification, repair and allied technical services pertinent to information processing and interpretation equipment now installed in laboratories in Washington, D. C., and other areas.

5. Provision of specialized personnel to Government laboratories and facilities to supplement their work forces.

Facility

 [redacted] occupies a new 45,000 square-foot building
 [redacted] on Route 70-S. Facilities for custom design and

production are among the principal elements available in this plant which contains an Electronics Laboratory, Materials Laboratory, Model Shop and Environmental Test facility, and Photographic Laboratory. The most rigid security standards and precautions are maintained throughout.

Related Experience

STAT 1. [redacted] has recently contracted to deliver "Mobilab," (QRC-250) to the Air Force under Contract [redacted] The M-3 STAT (EH-68) processor, contained within "Mobilab," is designed to utilize the diffusion transfer process of [redacted] (Bimat). STAT In addition to the six processors per van, an imbiber (FS-4) for presoaking the Bimat and storage containers for the presoaked Bimat are provided. The "Mobilab" (ES-53) is a completely self-sufficient vehicle, providing all power and environmental controls for the M-3 Processor and work area. The "Mobilab" will process and deliver a positive and negative at an aggregate rat e of 240 fpm.

STAT 2. [redacted] has also contracted to deliver two "Minilabs" to the USMC

STAT under contract no. [redacted] The primary function is to provide a compact, lightweight field transportable system, capable of processing exposed photographic film utilizing the Bimat process. The "Minilab" will be 20 inches long, 15 inches high and 10 inches wide, weighing 50 pounds unloaded, and be capable of processing 70 mm. and/or 5-inch wide film.

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